Transmission of Staphylococci in the Critical Care Environment

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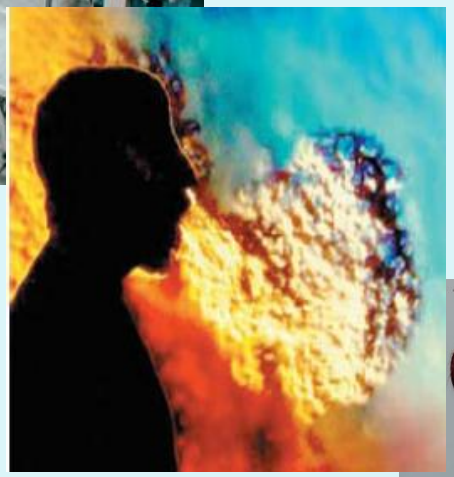
What are the main pathogen reservoirs?

Hands

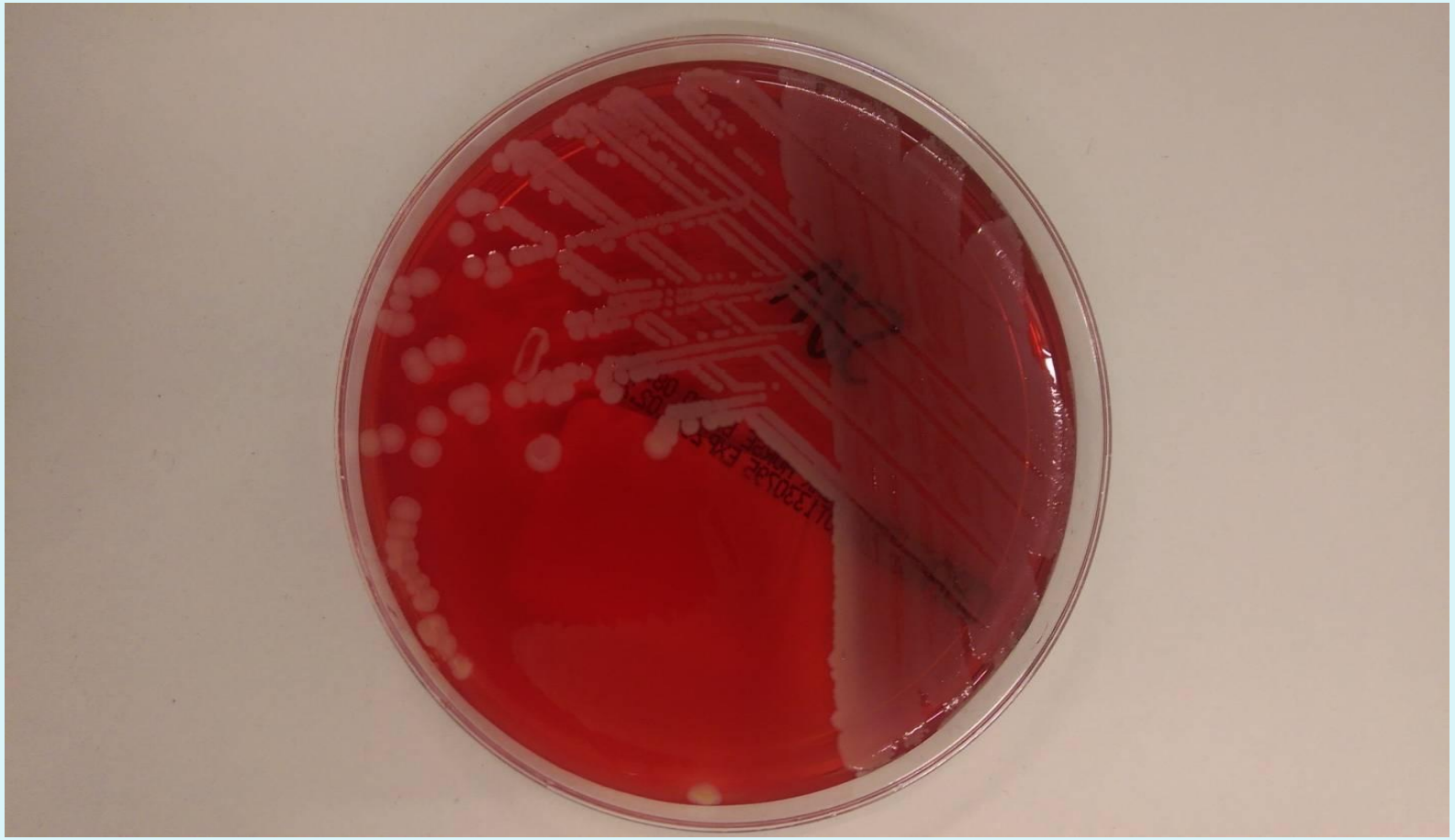
Environment

Air

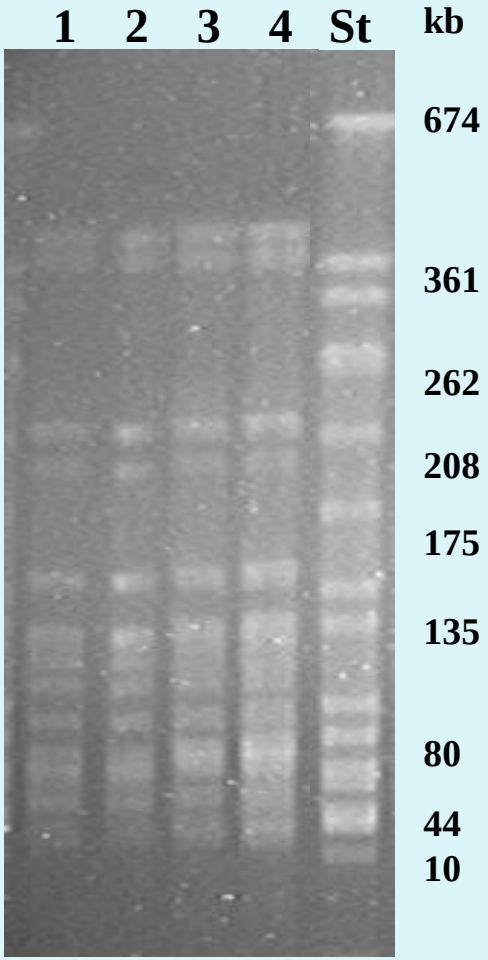


People

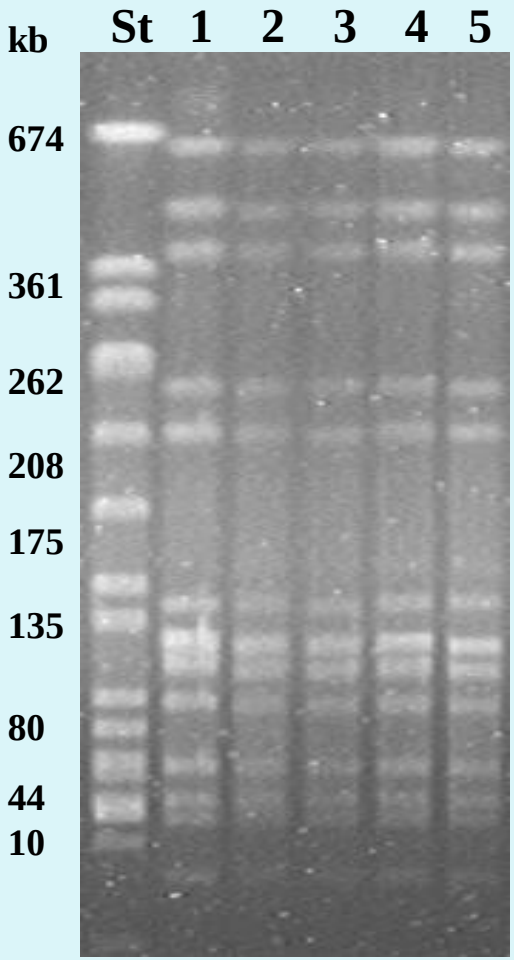
What's so special about *S.aureus*?



Identical PFGE patterns demonstrated by staphylococci from a nurse's hand, patient blood and ITU environment



PFGE patterns of CNS chromosomal DNA digested with *SmaI*. Lane 1 = computer keyboard; lane 2 = blood cultures; lane 3 = blood cultures; lane 4 = Hand-1, St = standard *S.aureus* NCTC 8325.

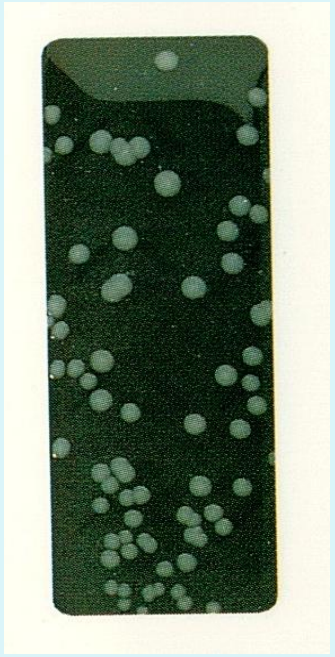


PFGE patterns of CNS chromosomal DNA digested with *SmaI*. St = standard *S.aureus* NCTC 8325; lane 1 = door handle; lane 2 = bed; lanes 3, 4 & 5 = blood cultures.

Dancer et al, AmJIC 2006

The Surface-Air-Sampling (SASS) study began January 2015

1. Patients: routine screening (*S.aureus*)
2. Near-patient sites (ACCs and *S.aureus*)
3. Staff hands (*S.aureus*)
4. Air- passive (ACCs and *S.aureus*)
5. Air- active (ACCs and *S.aureus*)



ACCs: aerobic colony counts

Protocol: Surface-Air-Sampling study

- Ten study days on 10-bed ICU during ten months
- All patient admissions screened for *S.aureus* throughout
- Five high-touch near-patient sites screened using dipslides
- Ten one-hour covert audits of hand-touch frequency of sites
- Anonymized sampling of ten staff hands on each study day
- Passive and active air sampling at four positions in ICU

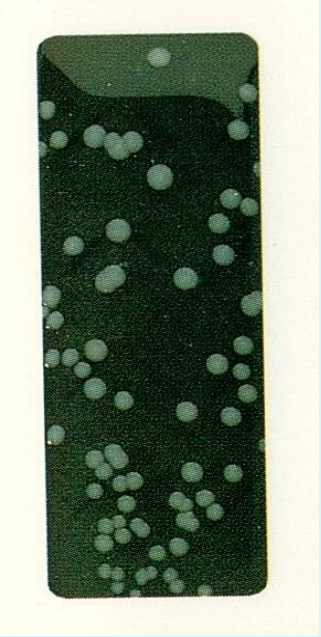
All S.aureus isolates were stored for further work.

What are the most frequently touched sites in ICU?

1. Infusion pump
2. Cardiac monitors
3. **Ventilation tubing**
4. Bed rails: Right and Left
5. End of bed table

Standardising aerobic colony counts on double-sided dipslides

Growth on nutrient agar supplied total aerobic colony count (cfu) per cm^2 as follows:



No growth (NG).....0 cfu/cm^2
Scanty growth (SG).....<2.5 cfu/cm^2
Light growth (LG).....2.5-12 cfu/cm^2
Moderate growth (MG).....12-40 cfu/cm^2
Heavy growth (HG).....>40 cfu/cm^2

Staph selective agar highlighted possible coagulase-positive staphylococci, which were identified according to routine laboratory protocol.

Air sampling

Active

MAS-100 NT® Microbial Air Monitoring System

Passive

One 9cm agar plate

One metre high

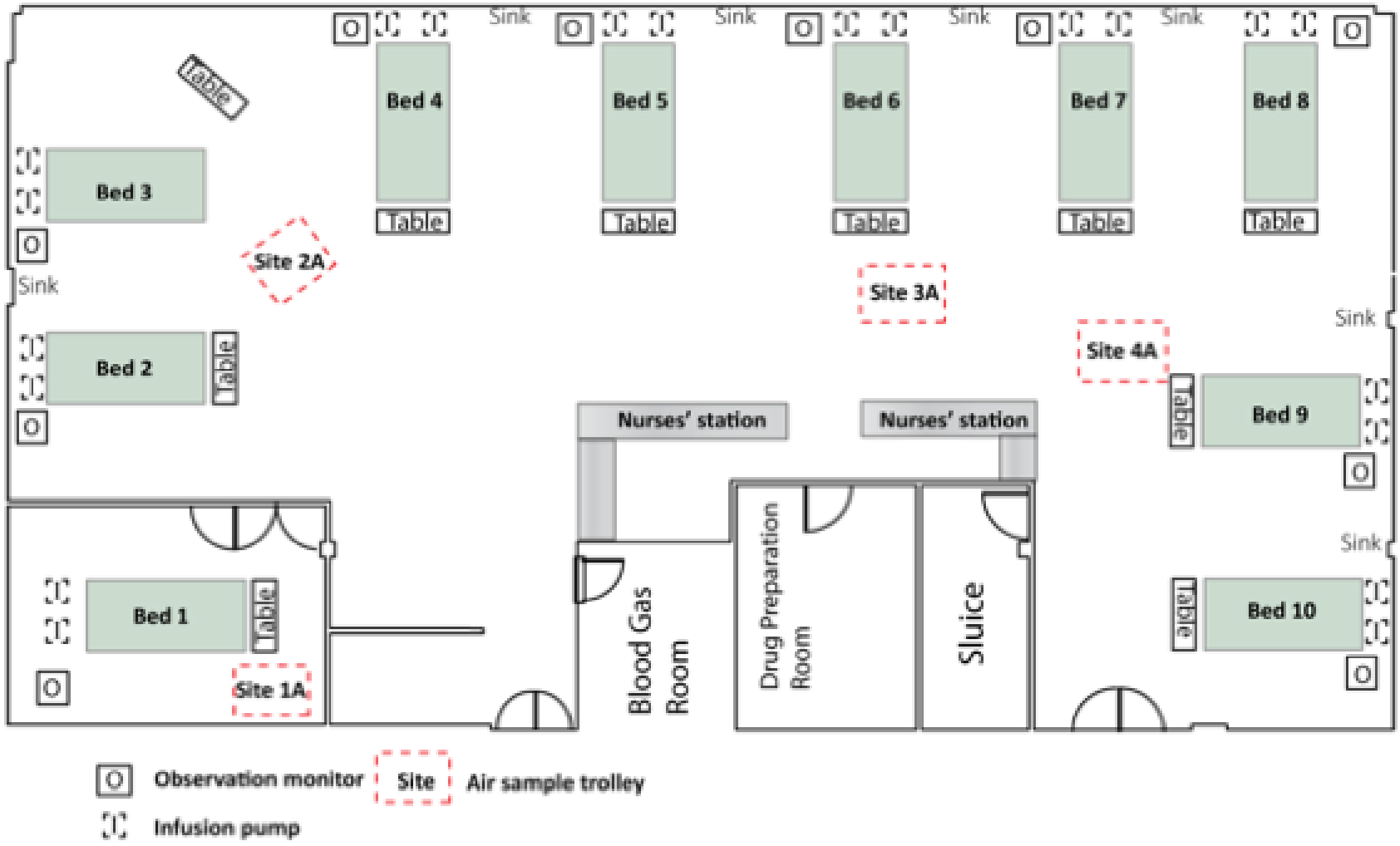
>One metre from a wall

One hour

Index of microbial air contamination (IMA)

Pasquarella C, J Hosp Infect 2004

Schematic plan of the Intensive Care Unit



Microbial contamination, MSSA/MRSA and hand-touch frequency of five sites

Site	No Growth	Scanty Growth <2.5 cfu/cm²	Light Growth >2.5-12 cfu/cm²	Moderate Growth >12-40 cfu/cm²	Heavy Growth >40cfu/cm²	MSSA MRSA Total	Gross soil >12 cfu/cm²	Hand touch frequency (average 10x1 hr audits)
Infusion Pump n=100	16	47 MSSA	22	13 MSSA	2	2	15	9
Cardiac Monitor n=100	45	28	16 MSSA	9	2	1	11	6
Right Bedrail n=100	6	38	17	27	12 MSSA	1	39	20
Bed Table n=100	13	35	33 MSSA	16 MSSA	3	2	19	37
Left Bedrail n=100	6	31	26	25 MSSA x2	12 MSSA & MRSA	4	37	16

Is there an association between gross microbial soil and frequency of hand-touch?

Figure showing the association between hand-touch frequency and gross microbial soil for five ICU sites

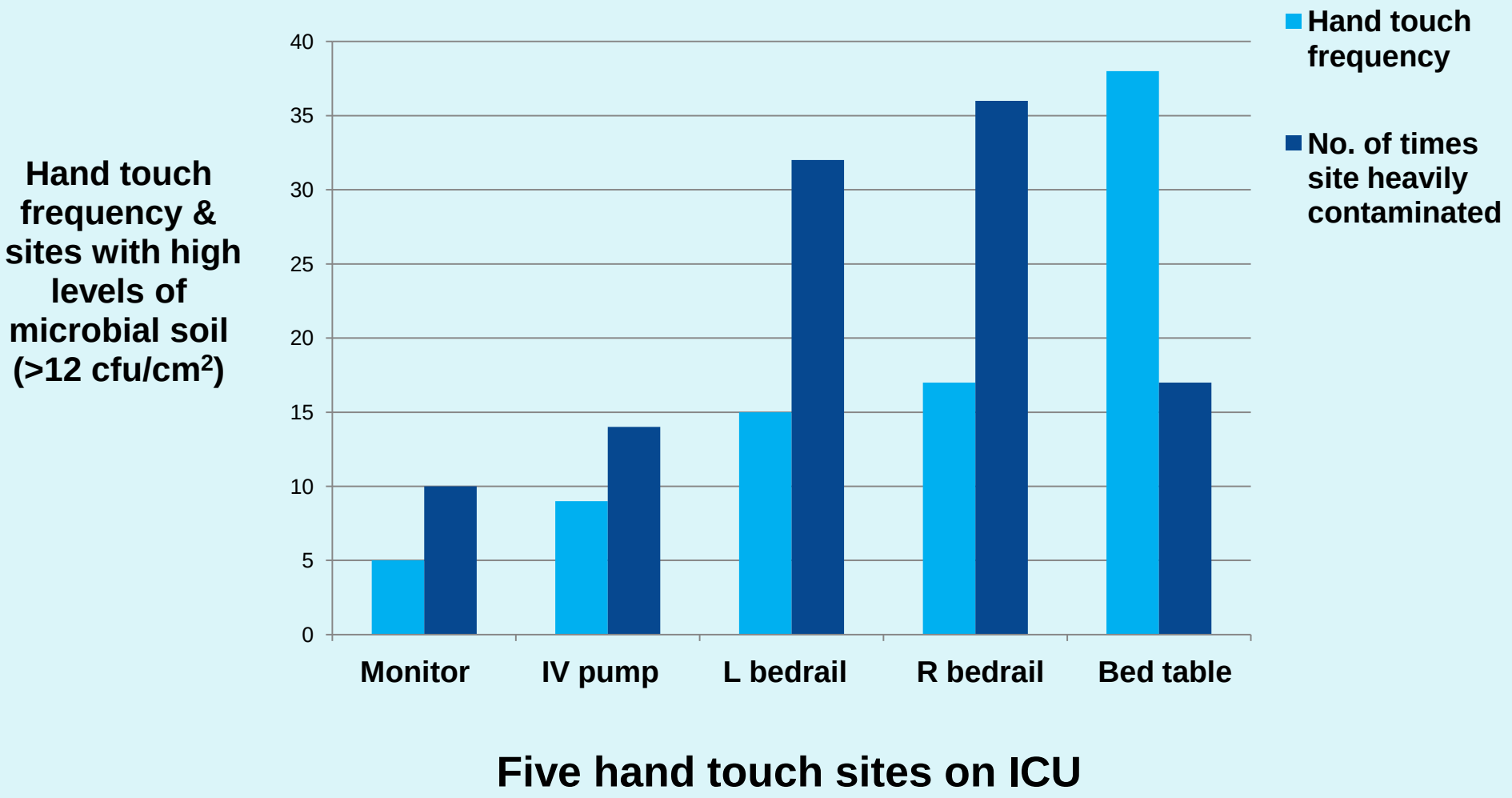
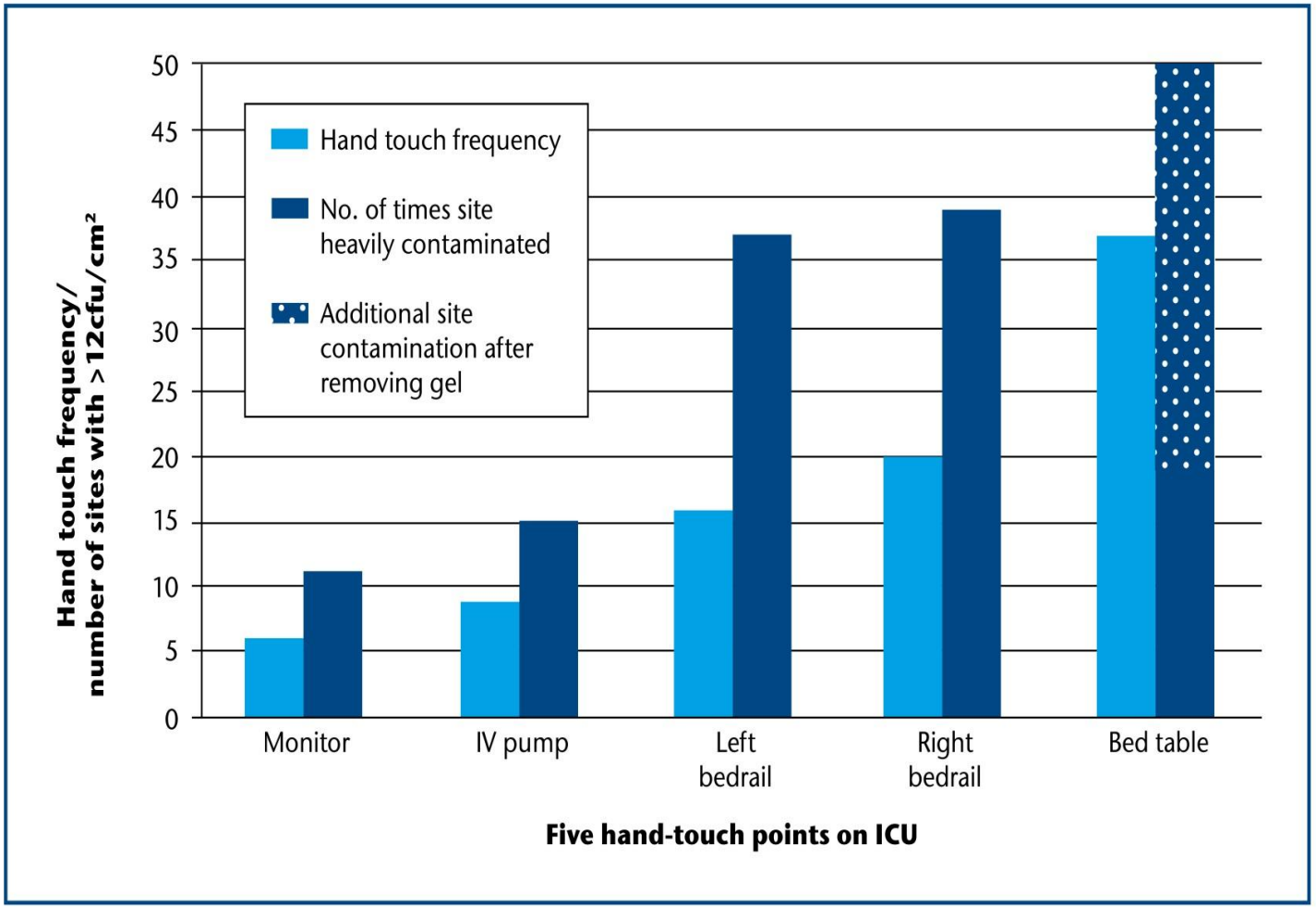


Figure 1: Hand touch frequency and gross microbial soil for five near patient sites on ICU



Adams et al, J Hosp Infect 2017

The Hand-Touch equation:

Hand

=

Hand-touch site

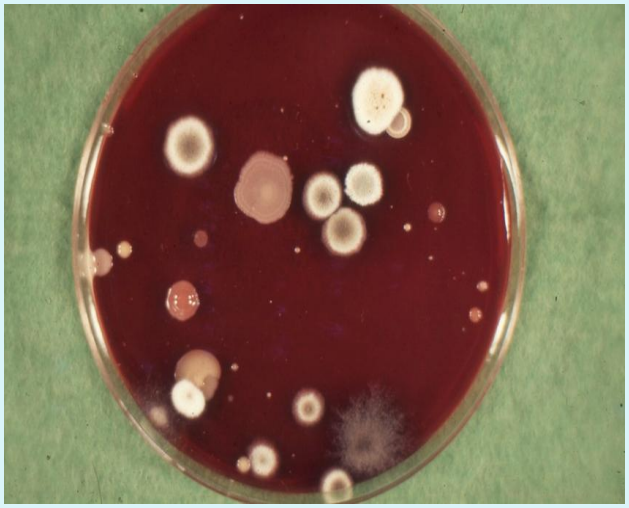
...is equal and opposite

Dancer SJ, ICHE 2010

Does the air contribute to HAI?

Active

Passive



Comparing microbial counts from surfaces and air in ICU using preset standards

Hygiene standard for surfaces: **<2.5 (5) cfu/cm^2**

Hygiene standard for air (passive): **≤2 cfu/9cm plate/hr**

Hygiene standard for air (active): **<10 cfu/m^3**

Dancer SJ, J Hosp Infect 2004; Pasquarella C, J Hosp Infect 2004

Hygiene status of microbial soil categories for five sites on ICU

Site N=100	No Growth	Scanty Growth <2.5 cfu/cm^2	Light Growth >2.5-12 cfu/cm^2	Moderate Growth >12-40 cfu/cm^2	Heavy Growth >40 cfu/cm^2	No. of Hygiene fails
Infusion Pump	16	47	22	13	2	37/100 = 37% FAILS
O2 Monitor Screen	45	28	16	9	2	27/100 = 27% FAILS
Right Bedrail	6	38	17	27	12	56/100 = 56% FAILS
Over-bed Table	13	35	33	16	3	52/100 = 52% FAILS
Left Bedrail	6	31	26	25	12	63/100 = 63% FAILS

Hygiene standard for surfaces: <2.5 cfu/cm^2 , thus average surface fail = 47%

Table to show hygiene status of microbial bioburden categories for passive and active air samples on ICU

	No Growth	Scanty Growth <2.5 cfu	Light Growth >2.5-10 cfu	Moderate Growth >10-40 cfu	Heavy Growth >40 cfu	No. of Hygiene fails
Air settle N=40 (passive) cfu/9cm^2/hr	1	19	18	2	0	20/40 = 50% FAILS
Air sampler N=40 (active) cfu/m^3	1	6	18	15	0	15/40 = 37.5% FAILS

Hygiene standard for air (passive): ≤2 cfu/9cm plate/hr; for air (active): <10 cfu/m^3

Overall 50% passive air samples fail; 37.5% active air samples fail

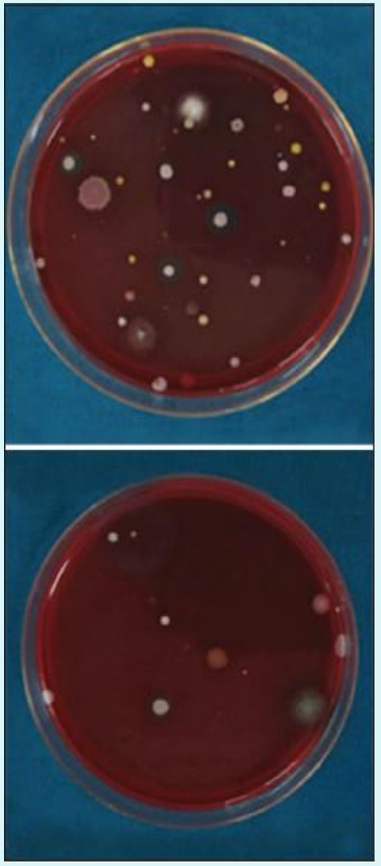
Does microbial contamination in the air reflect what's on surfaces?

Overall **47%** surfaces fail the surface standards

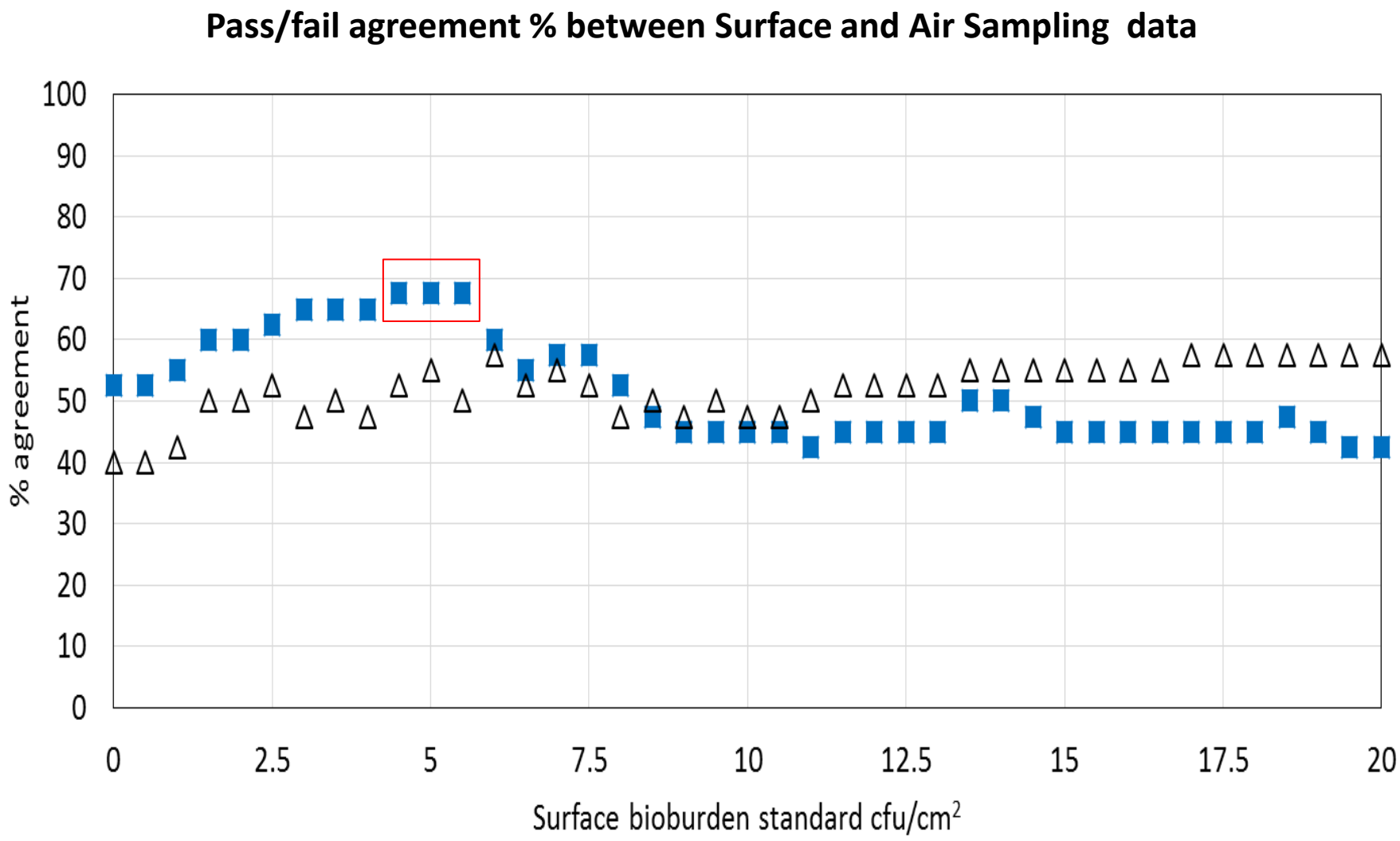
At least **50%** passive air samples fail

Approx. **37.5%** active air samples fail

So, pass/fail proportion of microbial counts on **settle plates** (*passive* air sampling) more closely resembles pass/fail proportion of **surface counts** from near-patient hand-touch sites



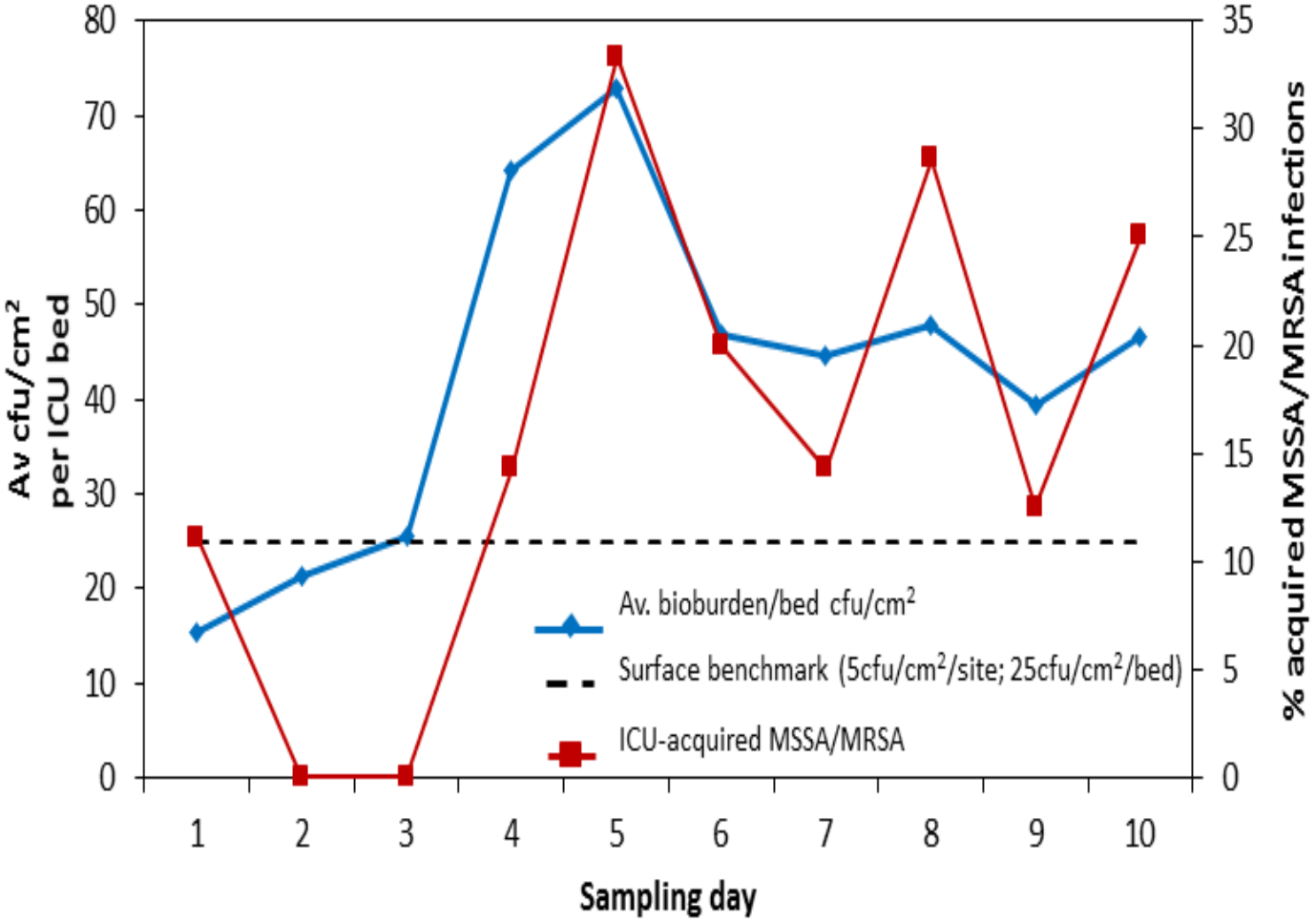
Is surface bioburden associated with air bioburden?



Smith et al, J Hosp Infect 2018

What else is surface bioburden associated with?

Smith et al, J Hosp Infect, 2018



Bioburden/bed is associated with MSSA/MRSA acquisition rate

Genotyping of *S.aureus* from surfaces, staff hands, air and patients*

Surfaces.....10 isolates

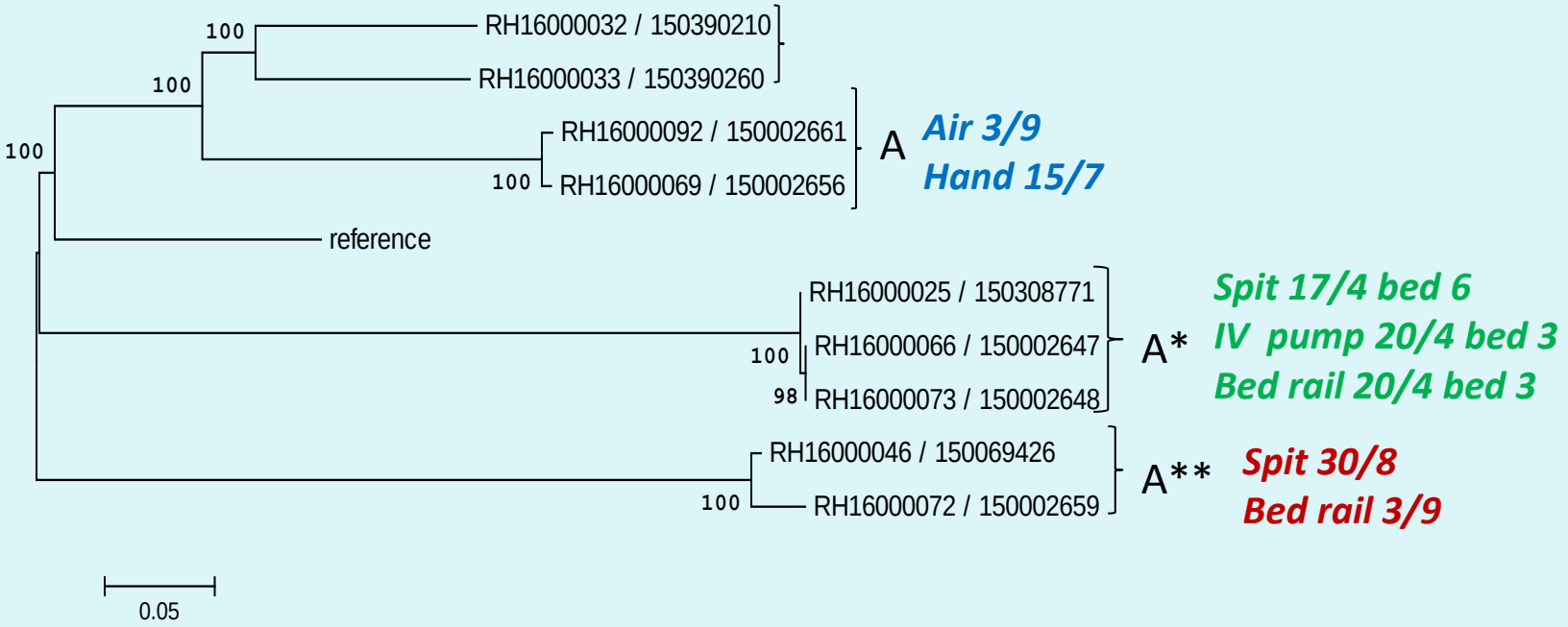
Staff hands.....10 isolates

Air.....4 isolates

Patients (total).....143 (25*) isolates

*** Resident on ICU on sampling days**

ML tree Group 1-CC5 *S.aureus*



Single nucleotide polymorphism (SNP) phylogenetic analysis

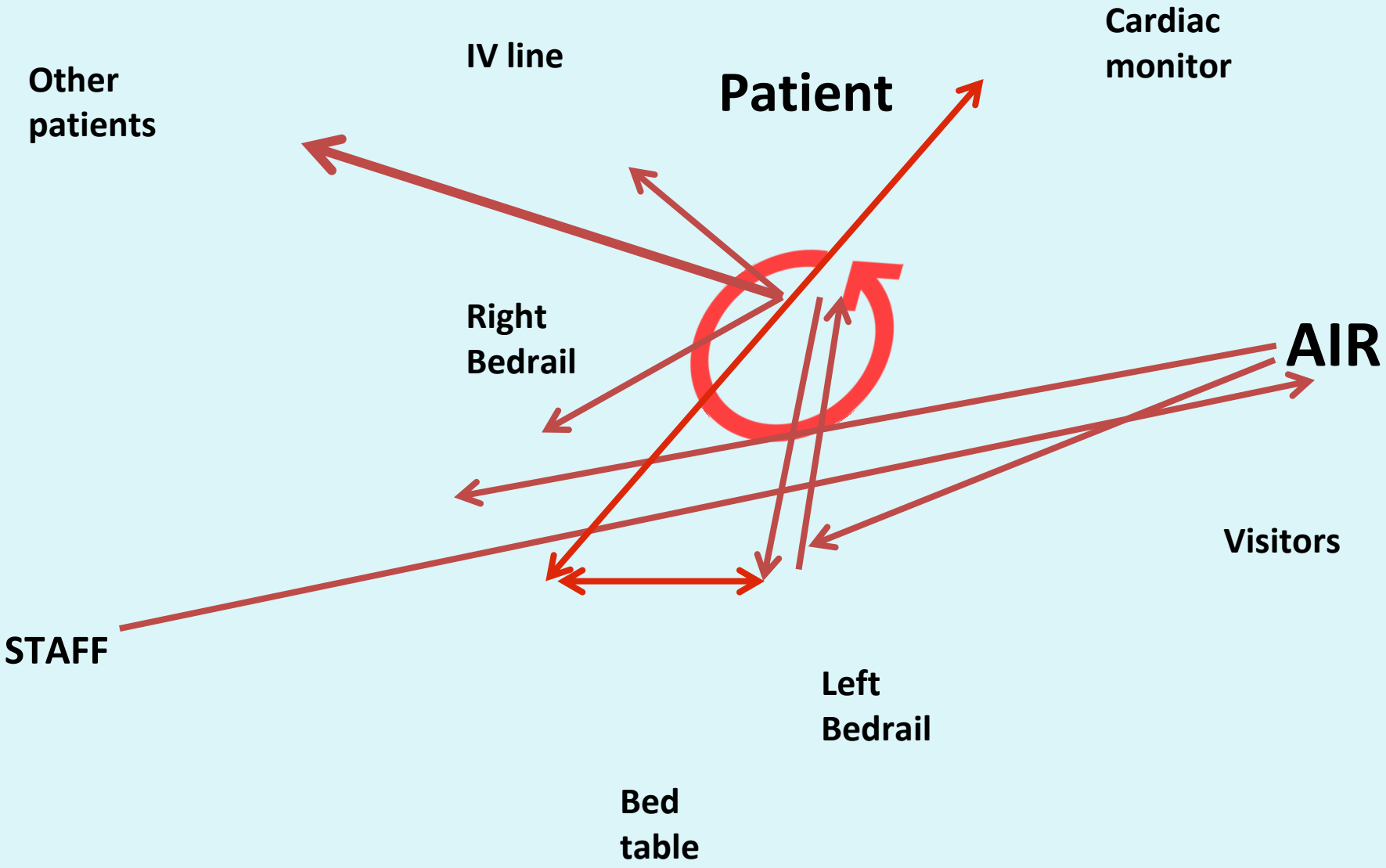
	ID	1	2	3	4	5	6	7	8	9	REF
RH16000025 / 150308771	1	0									
RH16000032 / 150390210	2	567	0								
RH16000033 / 150390260	3	547	222	0							
RH16000046 / 150069426	4	557	565	543	0						
RH16000066 / 150002647	5	3	576	556	562	0					
RH16000069 / 150002656	6	598	330	323	591	606	0				
RH16000072 / 150002659	7	575	584	561	37	580	609	0			
RH16000073 / 150002648	8	3	573	554	560	0	605	578	0		
RH16000092 / 150002661	9	596	330	323	589	604	12	607	603	0	
reference	REF	480	363	333	473	490	393	490	489	392	0

Conclusions from phylogenetic tree analyses

- Of 34 transmission events involving identical strains, 22 (65%) were autologous; so, nearly **two-thirds** of ICU-acquired *S.aureus* infection originated from the patients' own flora.
- There were 4 (12%) transmission pairs linking patients with hand-touch sites (bedrails & iv pump);
- There were 3 (9%) episodes showing cross-transmission between patients; and 2(6%) transmission pairs linking bedrail, table & monitor;
- Transmission events involving air were found 3 (9%) times but these occurred between staff hands and bedrail, not patients.

No links were found between staff hands and patients!

Dancer et al, submitted JHI 2018

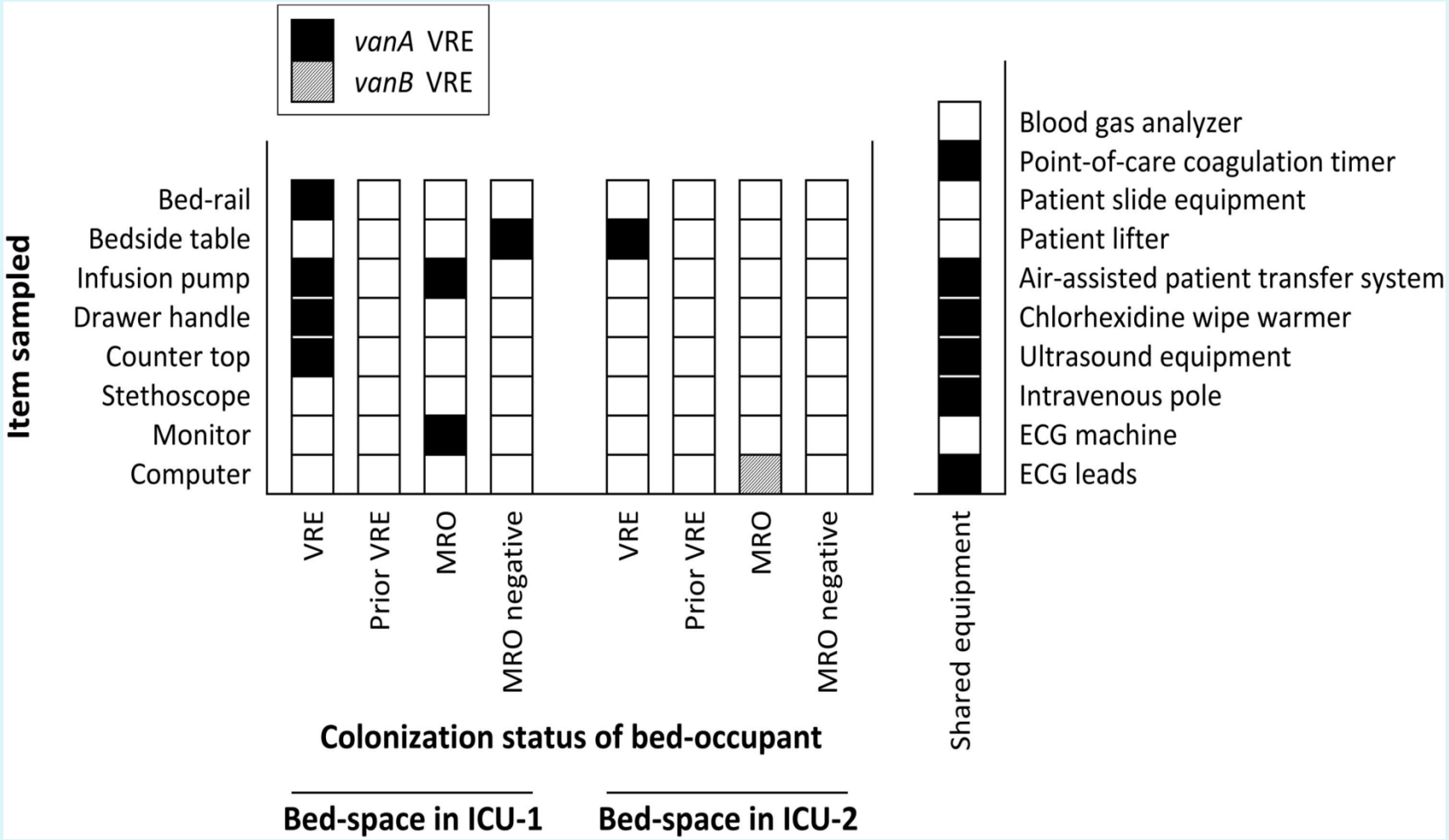


CONCLUSIONS

- Frequently touched surfaces demonstrate **higher** amounts of microbial soil;
- Air counts (from settle plates) are associated with microbial counts on surfaces;
- Surface counts are associated with ICU-acquired staphylococcal infection
- *Staph. aureus* spreads between surfaces (furniture & equipment), patients, staff hands and air in ICU.

The main direction of transmission is autologous!

Figure showing isolation of vancomycin-resistant enterococcus (VRE) from environmental samples.



Lee et al, ICHE 2018, in press

What should we do to protect patients from staphylococcal acquisition in critical care?

- Admission screening of patients;
- Clean near-patient hand-touch surfaces;
- Continued emphasis on hand hygiene for staff;
- Hand hygiene policy for visitors?

ACKNOWLEDGEMENTS

Claire Adams, Anaesthetics, Edinburgh Royal Infirmary
Jenny Smith, Microbiology, Hairmyres hospital
Veronica Watson, ICU, Hairmyres hospital
Chris Robertson, Strathclyde University
Janice McLaren and Microbiology staff, Hairmyres hospital
ICU nurses, Hairmyres hospital
Raymond Hamill, R&D Director, NHS Lanarkshire
Angela Kearns & Bruno Pichon, HPA, London
Cath Noakes & Marco-Felipe King, Leeds University

NB. No disclosures